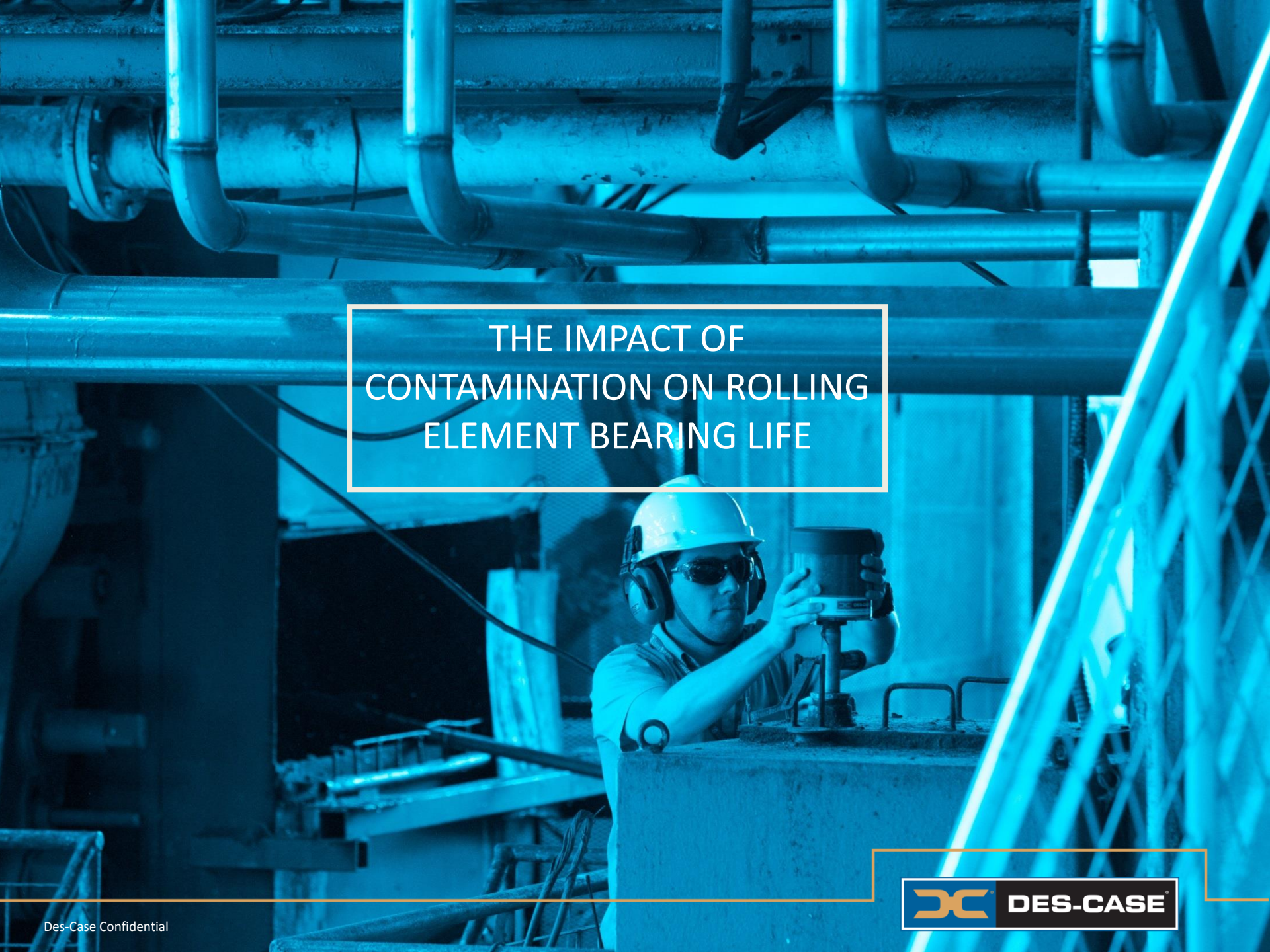
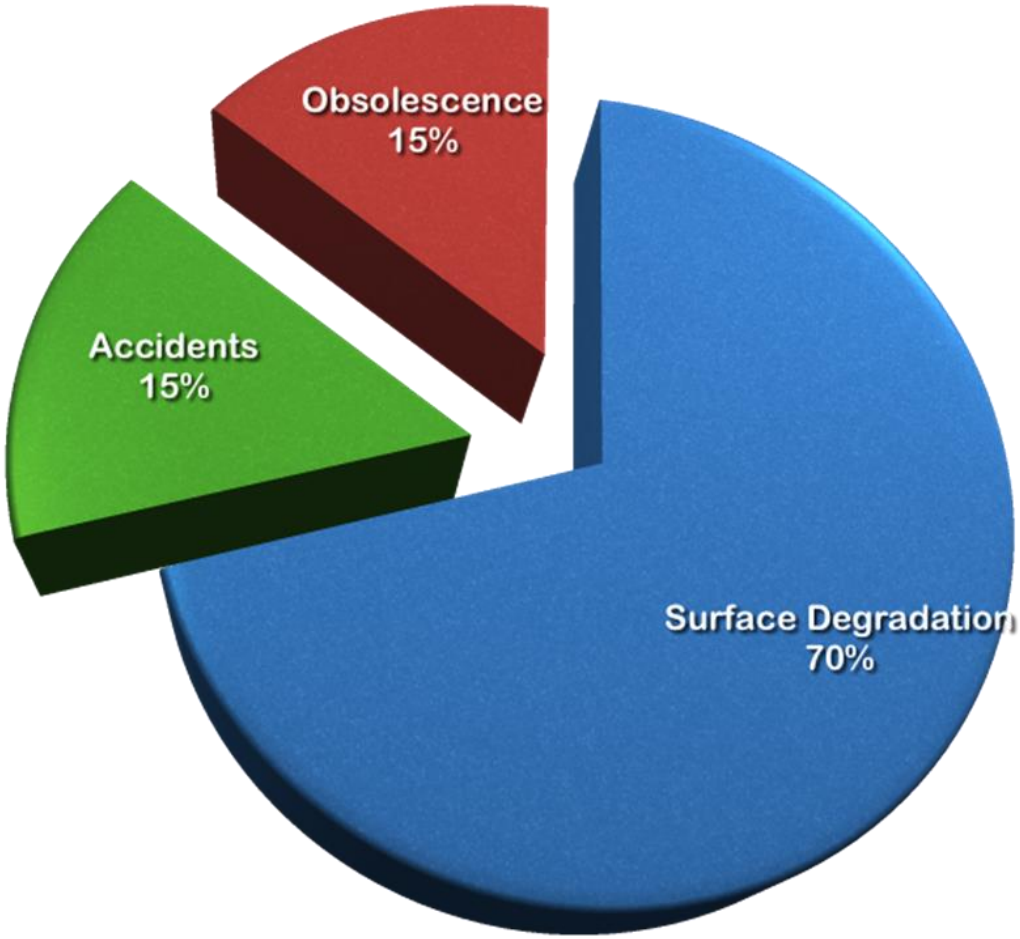


THE IMPACT OF CONTAMINATION ON ROLLING ELEMENT BEARING LIFE

DES-CASE

What Causes Machines to Fail?



Loss of Usefulness

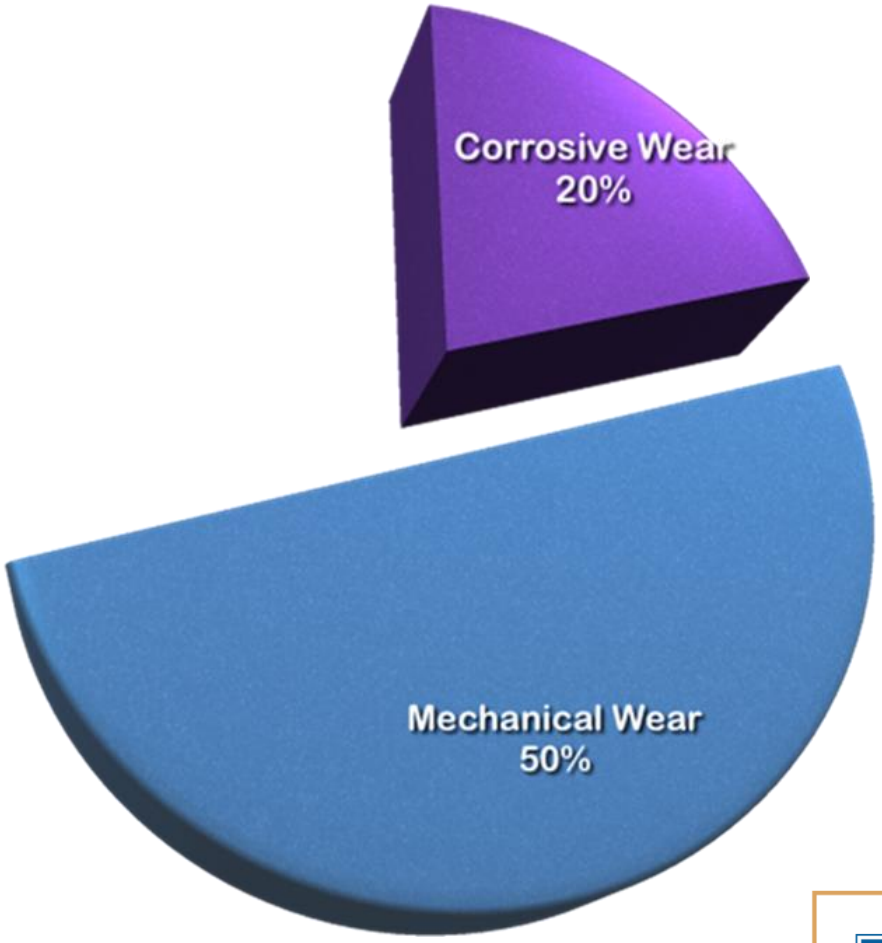
70% of loss of machine life is due to loss of surface material

Ref: MIT, E. Rabinowicz

DES-CASE

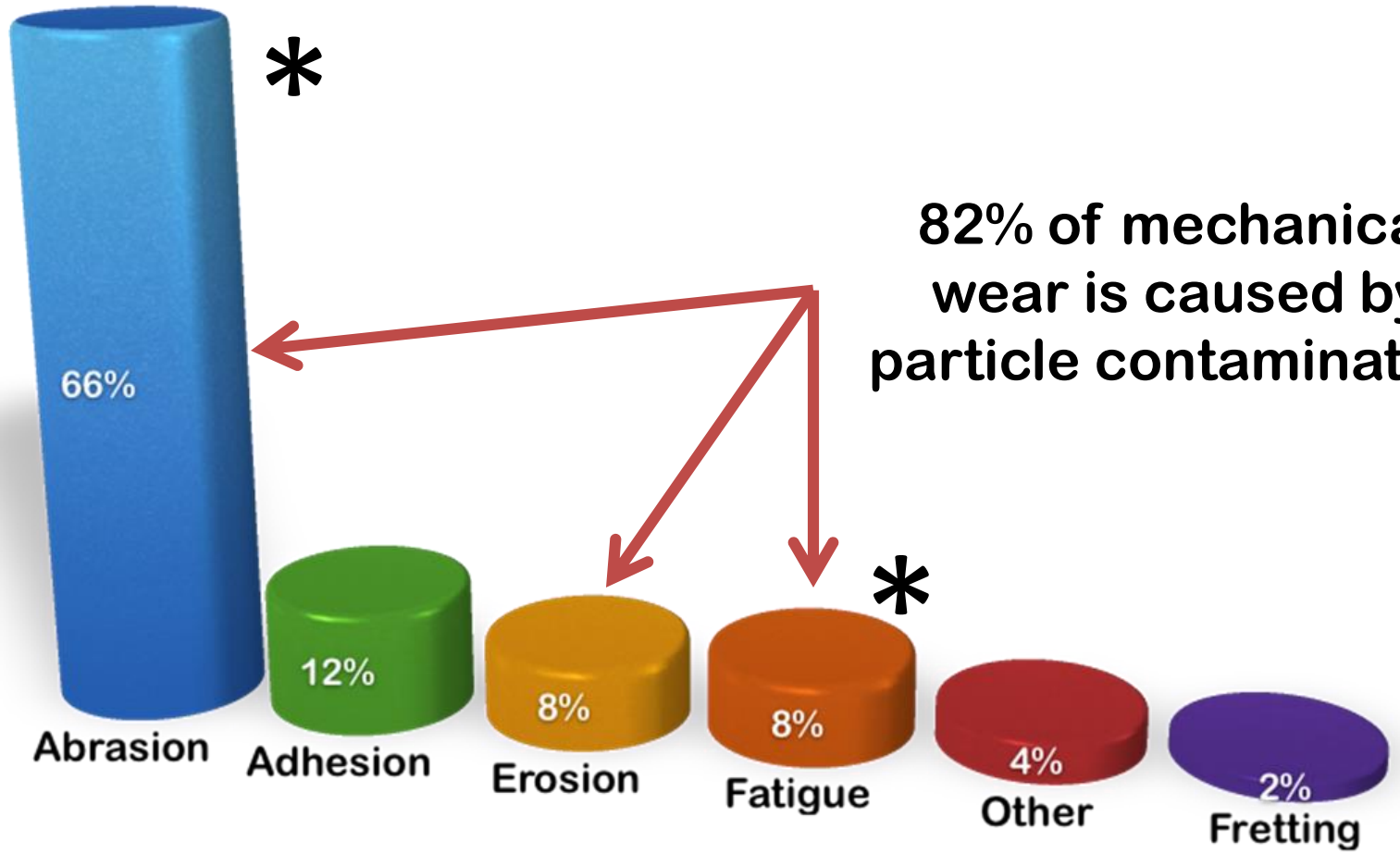
What Causes Surface Degradation?

Surface Degradation



Ref: MIT, E. Rabinowicz

What Causes Machines to Wear?



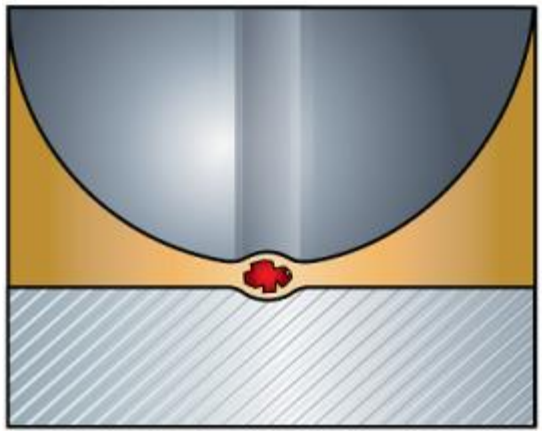
82% of mechanical wear is caused by particle contamination

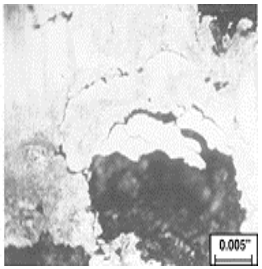
* *Most common lubrication related failure modes for rolling element bearings*

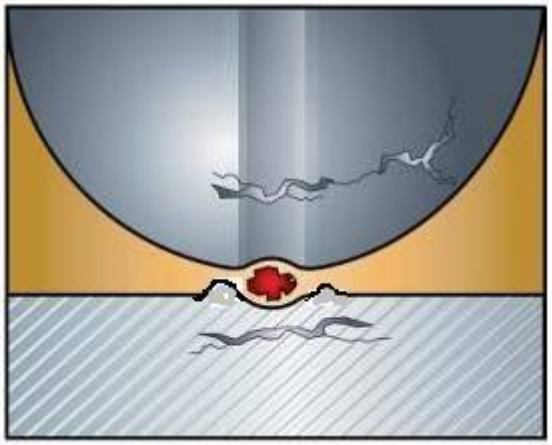
Ref: NRCC, STLE

DES-CASE

Contact Fatigue





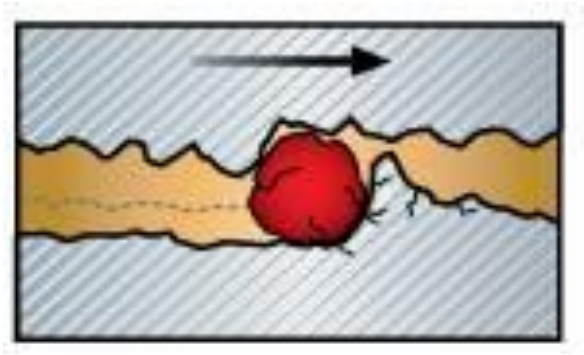


Where it occurs: Particle-induced fatigue pitting can occur anytime clearance sized particle exist between surfaces in rolling contact (EHD films).

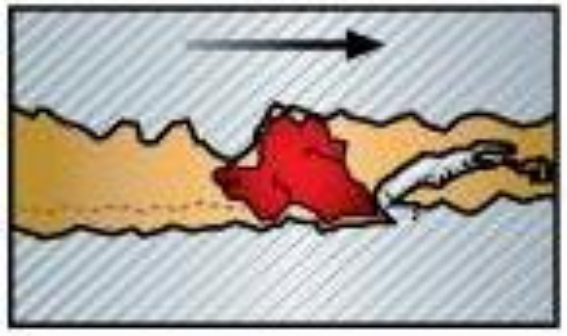
How to stop it: Particle-induced fatigue wear can be reduced or eliminated by removing clearance-sized particles from the oil or increasing the oil's film thickness beyond the size of the particles.

Three-body Abrasion

Plastic Flow



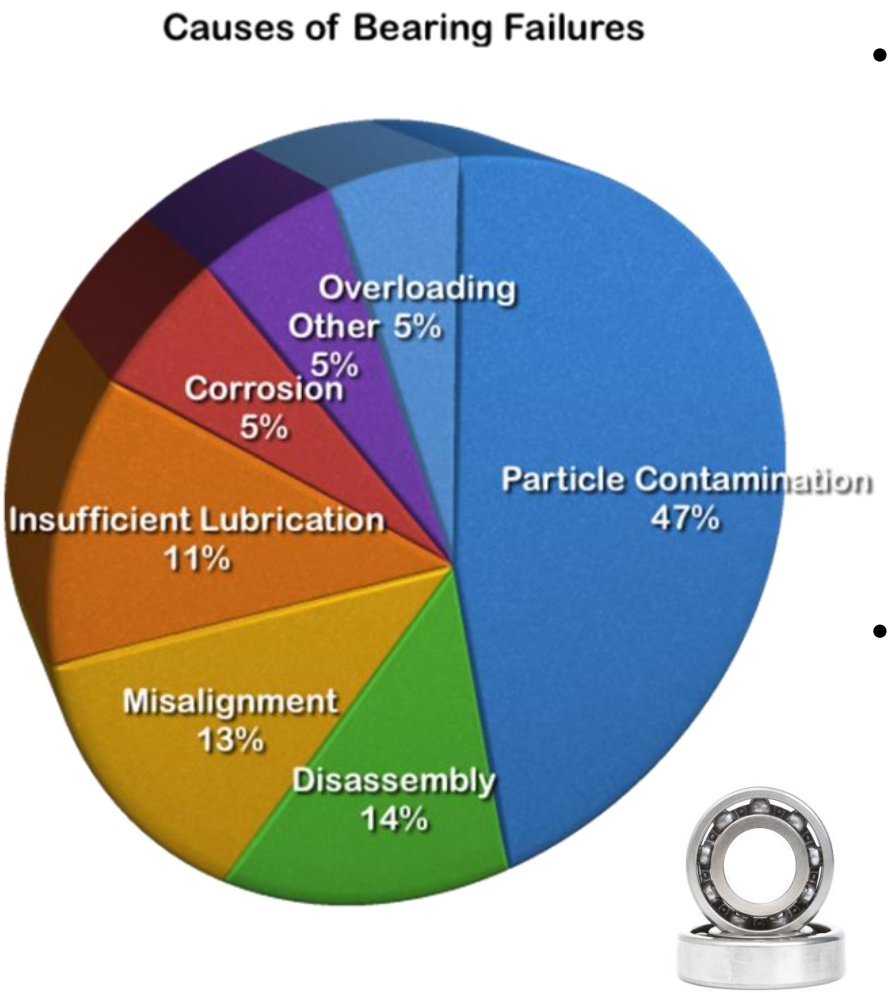
Cutting



Where it occurs: Three-body abrasion occurs any time clearance-sized particles are present in the oil between two surfaces in sliding contact.

How to stop it: Three body abrasion can be reduced or eliminated by removing clearance-sized particles from the oil or increasing the oil's film thickness beyond the size of the particles.

What Causes Bearings to Fail?



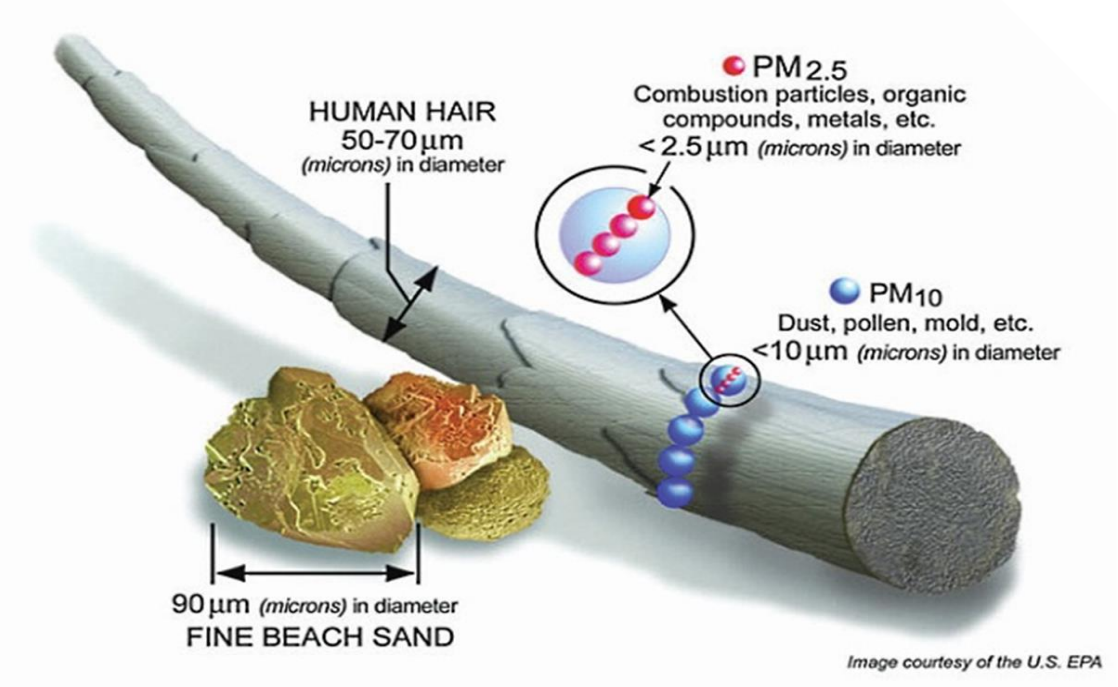
- **Specific to rolling element bearings, it has be estimated that over 50% of bearing failure are induced by contamination**

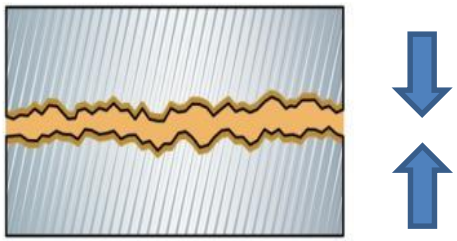
- **According to SKF “bearings can theoretically have an infinite life, provided particles the same size as the lubricant film are removed”**

DES-CASE

How Big is a Micron? How Big is the Oil Film?

In most rolling element bearings the dynamic clearance between the rollers and raceways under load/speed is the same size as pollen, soot or red blood cells





Dynamic clearance = 0.1-10 microns

Oil and Water *do* Mix

States of Coexistence

Dissolved Water

Can effect oil life by increasing oxidation rates and degrading additives.

Emulsified Water

Causes machine wear via corrosion, cavitation and loss of film strength. Shortens oil life by increasing oxidation, additive degradation and water washing.

Free Water

Serves to indicate that the oil has reached saturation for dissolved and emulsified water

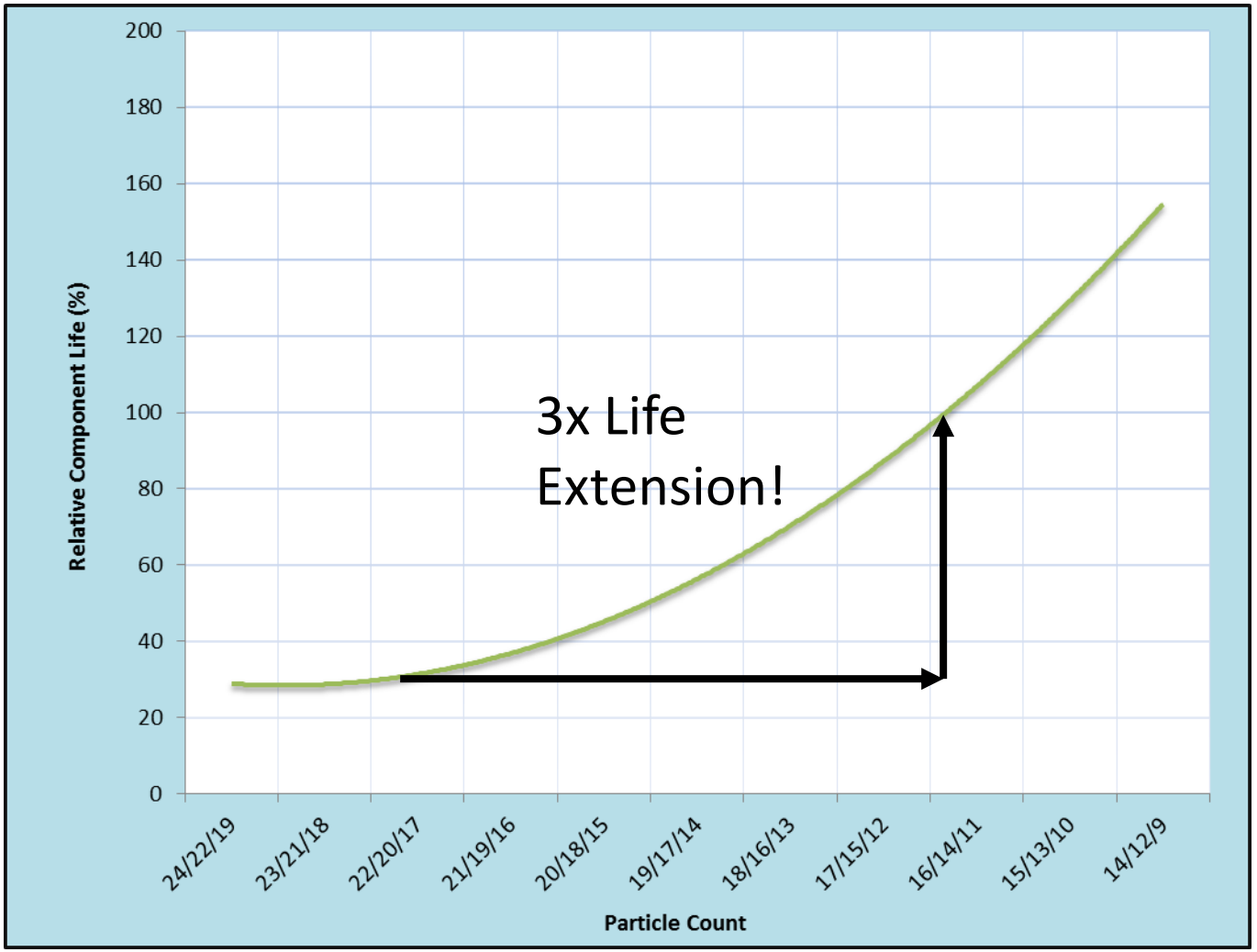
Factors that affect demulsibility

- Viscosity
- Contaminants
- Loss of additives
- Oil type
- Oxidation
- Temperature

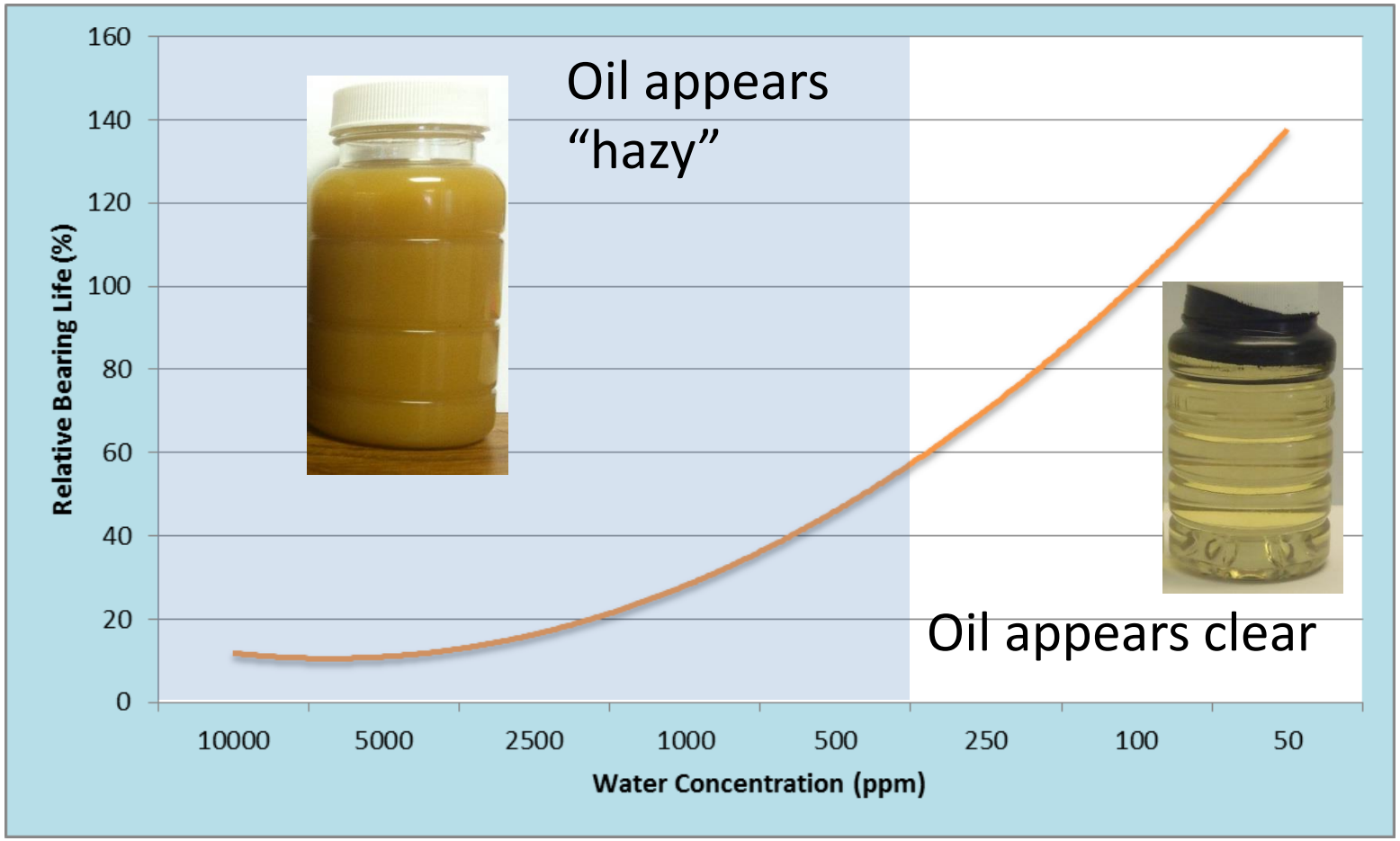
Effects of Contamination on Bearing Life

Damage Caused by Contaminant Type	Direct Machine Wear	Damage to Lubricant	Indirect Damage
Particle Contamination	• Abrasion • Fatigue	• Oxidation • Particle Scrubbing • Viscosity Increase	• Varnish / Deposits • Corrosive attack • Increased aeration
Moisture Contamination	• Corrosion (rust, fretting corrosion etc.) • Cavitation erosion (journal bearings)	• Oxidation • Hydrolysis • Water Washing • Viscosity Increase	• Varnish / Deposits • Corrosive attack • Increase Aeration • Exacerbates all wear mechanisms due to loss of film strength

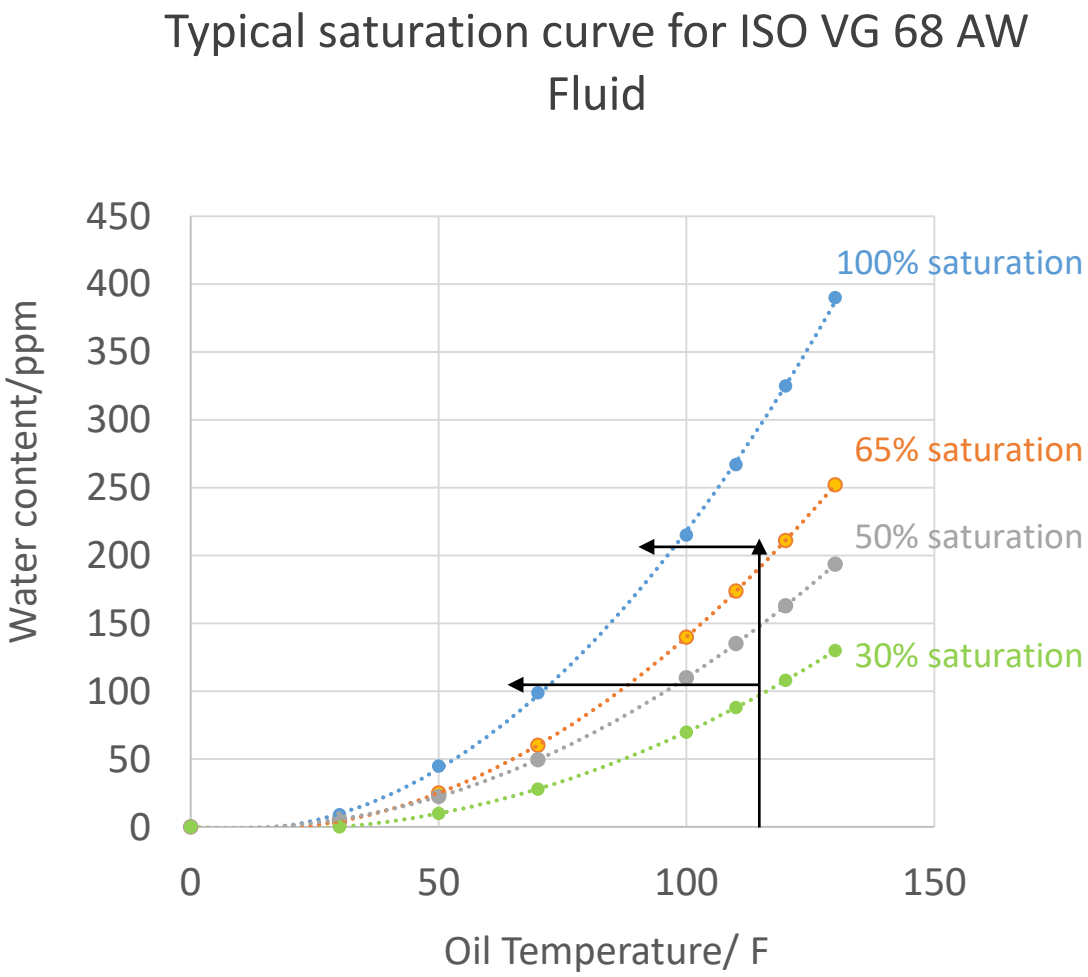
Effects of Particle Contamination on Bearing Life



Effects of Water Contamination on Bearing Life



Beware of Cycling Temperatures



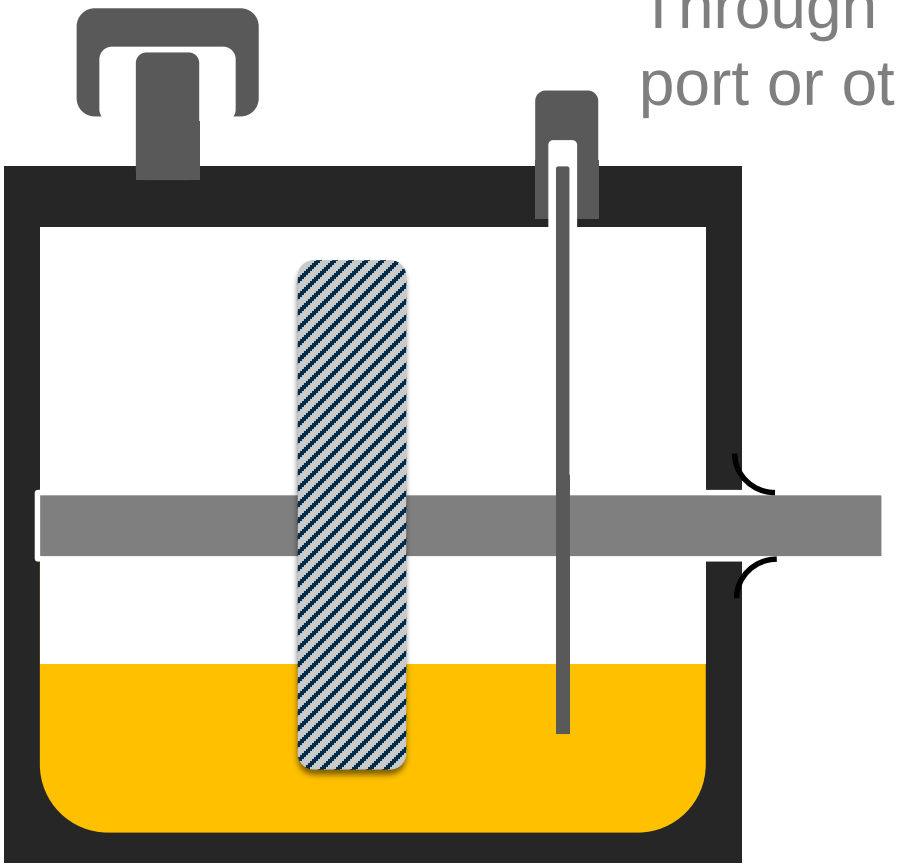
- When a machine shuts down and the oil cools, the relative humidity within the oil rapidly increase until the oil hits the dew point, resulting in free and emulsified water

DES-CASE

Sources of Moisture & Particle Ingression

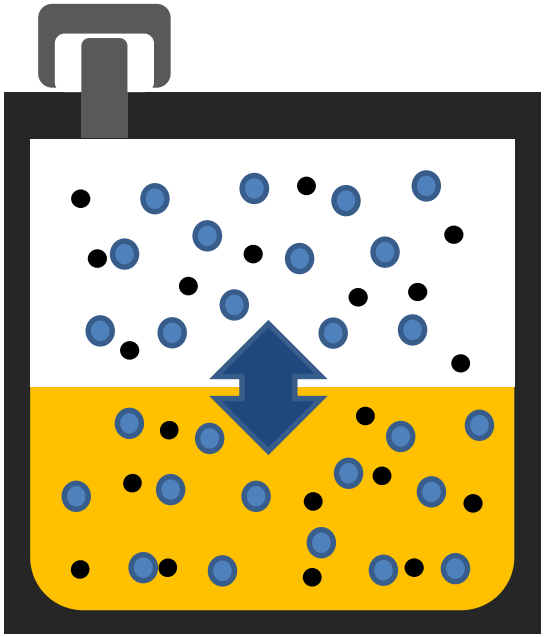
breather/vent during normal aspiration

Through the dipstick port or other open vent



Through the shaft seal due to wash down or normal ambient humidity

Headspace Management – the Key to Contamination Control



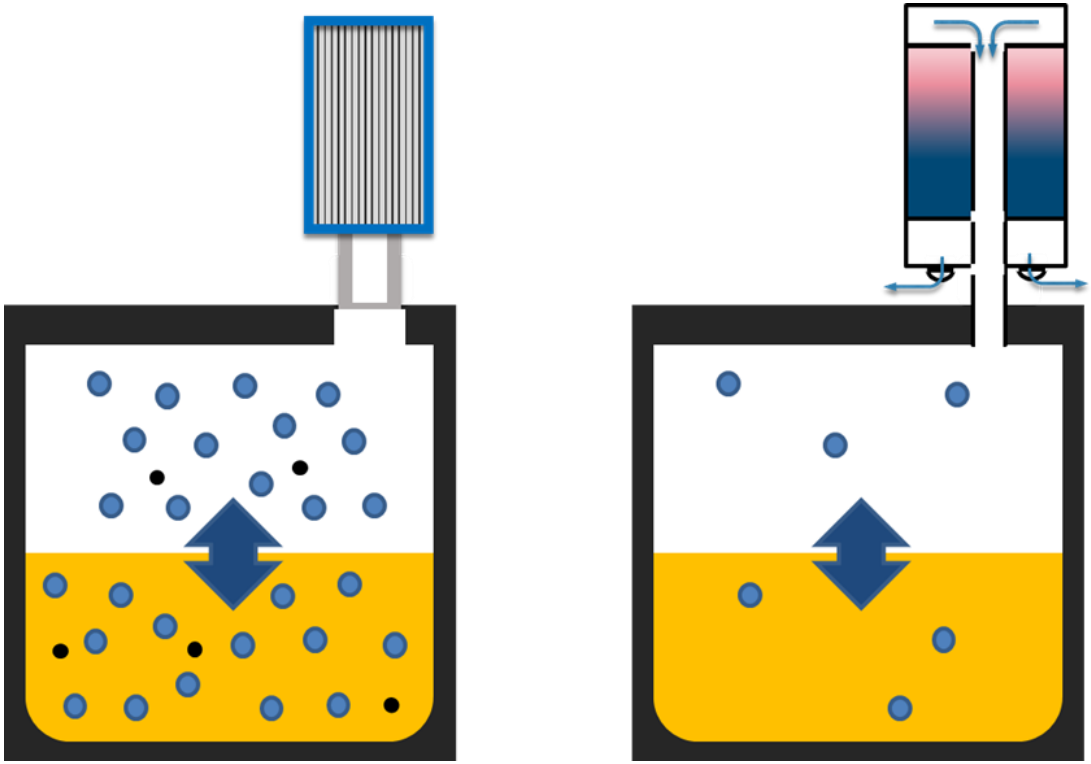
"At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid.“

Henry’s Law 1803

Strategies for headspace management

- Desiccant breathers
- Hybrid breather
- Nitrogen purge
- Conditioned air purge
- Expansion chambers

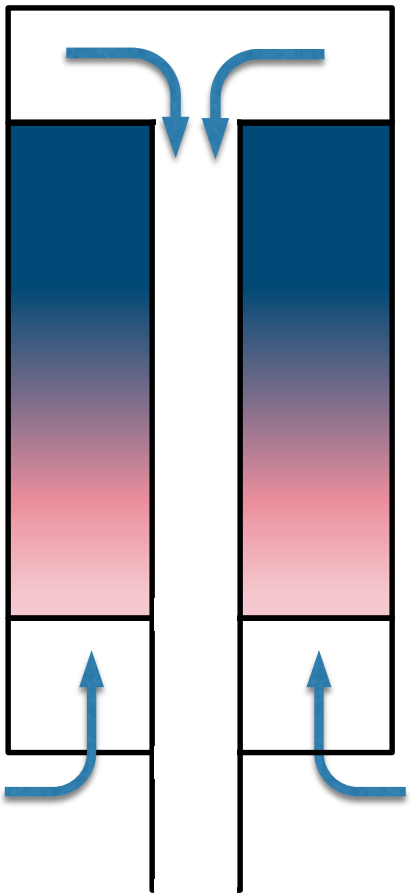
OEM Vent Port vs Desiccant Breathers



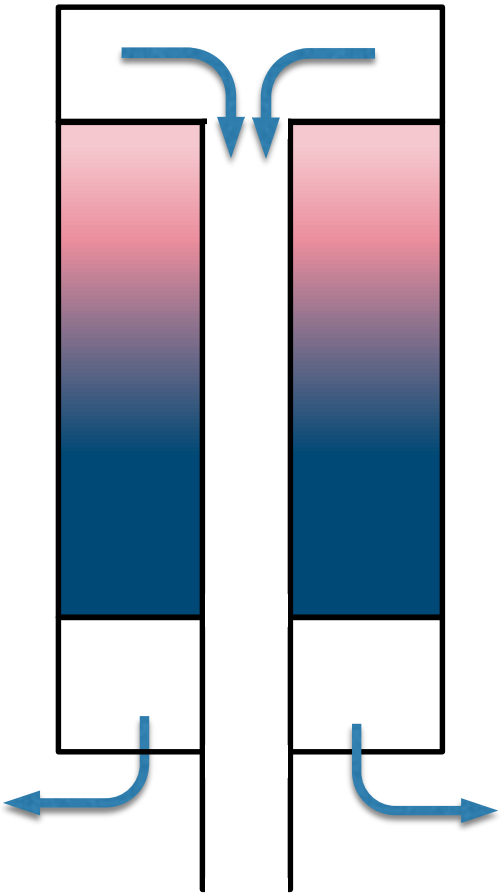
Upgrading basic vents or OEM fill ports to desiccant breathers helps control contamination

Controlling Headspace Cleanliness and Humidity

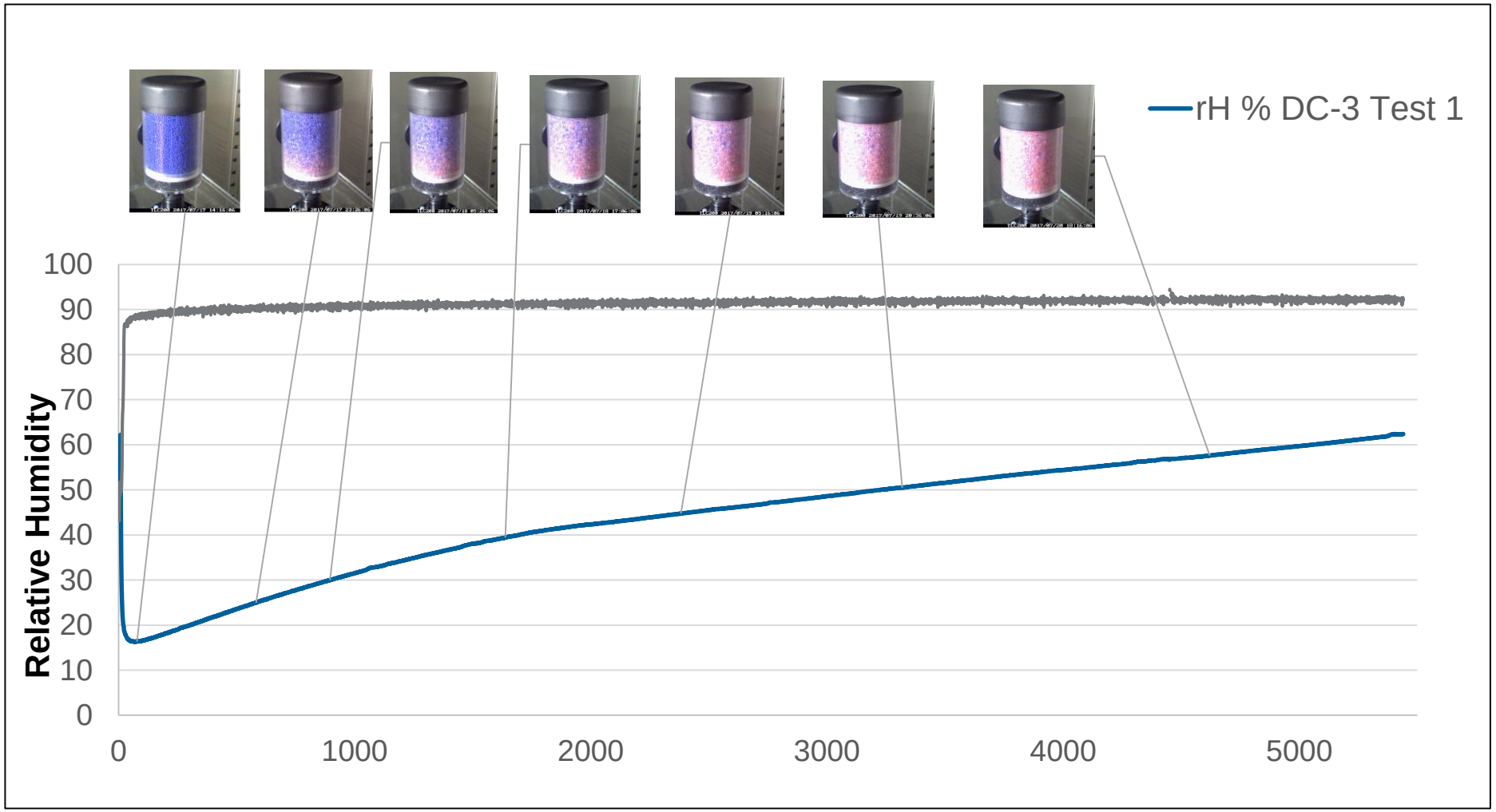
inhale



exhale

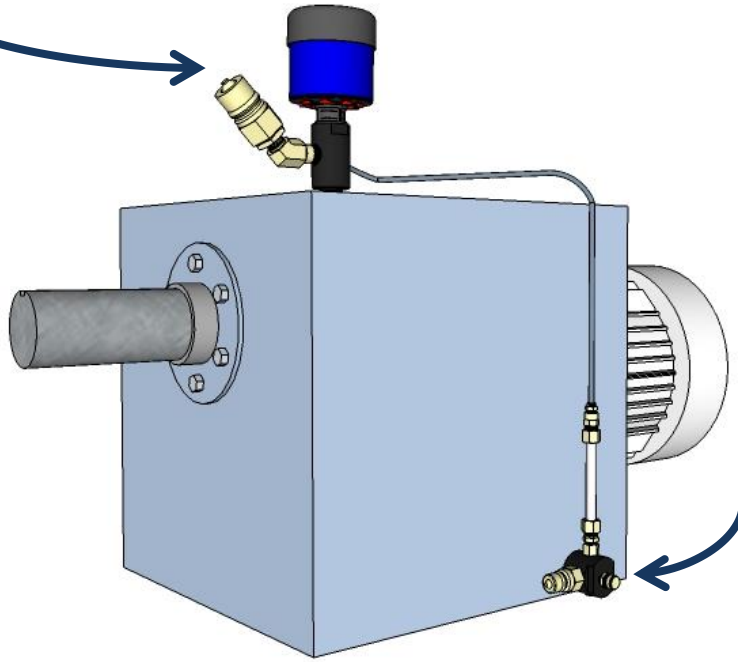


Desiccant Breathers Help to Maintain a Low Headspace Humidity



Additional Strategies for Controlling Contaminants

- Top off oil • Check oil level • Take oil sample
- Drain/fill oil • Kidney loop oil



Summary

- Over than 50% of bearing failures are due to water or particle ingression
- Particles the same size as a red blood cell (3 microns) can reduce bearing life by as much as 66%
- The best way to control oil cleanliness and dryness is to control the headspace cleanliness and humidity
- All lubrication tasks including oil changes and top-offs, sampling, levels etc. should be done without exposing the oil to the ambient environment


THANK YOU FOR YOUR
PARTICIPATION